Pro DNS and BIND

Dear Reader,

Every time you receive e-mail or access a web page, you use the Domain Name System (DNS). That makes DNS critical to the operation of the global Internet. However, this book is not a theoretical work about global concepts. It is about practical, real-world solutions. Every one of those requests originate from a DNS that supports a group of local users, and every one of them is finally answered by a DNS server that may support a high volume commercial web site or a modest personal mail server. This book is about understanding, configuring, diagnosing, and securing these local DNS servers that do the vital work.

I have been in the communications business as a programmer, designer, and systems administrator for over 30 years. Many years ago, when I set up my first pair of DNS servers, I wasted time searching for some practical advice and sensible descriptions of the theory involved. I found neither. I completed the DNS rite-of-passage—this book was born from that experience.

DNS is a complex subject, but it is also unnecessarily cloaked in mystery and mythology. This book, I hope, is a sensible blend of practical advice and theory. You can treat it as a simple paint-by-numbers guide to every task from a simple caching DNS to the most complex secure DNS (DNSSEC) implementations. But the background information is here for those times when you not only need to know what to do, but you also need to know why you are doing it and how can you modify the process to meet your unique needs.

Yours sincerely,

Ron Aitchison
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Pro DNS and BIND

Ron Aitchison

Book Information
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**DNSSEC Lookaside Validation**

The DNSSEC Lookaside Validation (DLV) service is an alternative method by which a chain of trust may be created and verified without the need to sign the parent zone file. The service makes use of a DLV RR, which is not currently defined by an RFC—its status is therefore experimental—but which is fully supported by the current (9.3+) versions of BIND. The DLV RR is functionally identical to the DS RR and may be generated by the `dnssec-signzone` utility by use of the `-l` domain-name option (see Chapter 9). A DLV RR is placed in a special signed zone called a *lookaside zone* instead of the DS RR that would normally be added to the parent zone, thus removing the need to sign the parent zone. The DLV service works by providing an alternative method to verify a chain of trust as described next.

Assume that the lookaside domain is called `dlv.example.net` and the name server is trying to verify the chain of trust for the signed zone `example.com`. In a normal sequence, when a security-aware name server tries to verify the chain of trust for `example.com`, it will first check for a trusted anchor in its `trusted-keys` clause, and if one is not found, it will issue a query to find a DS RR at the parent `.com` zone. If neither is found, the zone will be marked as insecure. DLV adds an additional step by allowing the name server to query a lookaside zone, for which it must have a trusted anchor, for the DLV RR of the zone being verified. When the verifying name server detects that the lookaside feature is enabled (by a `dnssec-lookaside` statement in `named.conf`), it will issue a DLV query with the domain name `example.com.dlv.example.net`, which, if found, and assuming the trusted anchor for `dlv.example.net` is present in a `trusted-keys` clause, the `example.com` zone is verified to be secure. Figure 11-7 illustrates the DLV process.

![Figure 11-7. DLV verification procedure](image)

The initial query will try to find a DS RR for `example.com` at the parent `.com` zone and only if that fails will the DLV query be issued to the lookaside zone. While the lookaside zone
dlv.example.net must be signed, the trusted anchor at NS1 means that its parent, example.net, does not have to be signed, as is shown in Figure 11-7.

A public pilot of DLV is currently being run by VeriSign Labs, a division of VeriSign, Inc. (www.verisignlabs.com), which covers *all* of the TLDs with a single trusted anchor, without the need for any of the TLD zones to be signed.

**DLV Configuration**

This section describes the various steps to be taken when joining the zone example.com to a DLV chain of trust. While the specific example of the VeriSign Pilot is used, the explanations cover the general case wherever appropriate. The lookaside zone for the VeriSign Pilot is dlv.verisignlabs.com.

The DLV system, like all other DNSSEC systems, starts with a signed zone. The example.com zone is signed in the normal way as described earlier using the `dnssec-signzone` utility with the addition of a `-l dlv.verisignlabs.com` option to create a DLV RR with the correct name (example.com.dlv.verisignlabs.com). Creation of this DLV RR is the only reason the zone needs to be re-signed. This step is actually not required for the current VeriSign Pilot project, which creates the DS RR automatically when a zone is submitted for addition to the pilot project. The process is described in full, since other DLV services may, however, require a DLV RR to be supplied.

Assuming the same configuration as the last example but using only the new KSK from the rollover (key-tag is 50148), the zone signing would use the following command:

```
# dnssec-signzone -o example.com -t -l dlv.verisignlabs.com \
-k Kexample.com.+005+50148 master.example.com Kexample.com.+005+39539 \
master.example.com.signed
```

Signatures generated: 20
Signatures retained: 0
Signatures dropped: 0
Signatures successfully verified: 0
Signatures unsuccessfully verified: 0
Runtime in seconds: 0.357
Signatures per second: 53.079

As noted previously, joining the VeriSign Pilot does not require a DLV RR, and since this is the only reason for re-signing the zone, it may be omitted if that is the only objective. The \ indicates that the line has been split for presentation reasons only, meaning the first and second lines actually appear as a single line to the operating system. The `-l dlv.verisignlabs.com` argument defines the name of the lookaside zone that will be appended to this zone name (defined by the `-o example.com` argument) when the DLV RR is created. This option causes `dnssec-signzone` to create a new file called `dlvset-example.com`, which contains a formatted DLV RR as shown here:

```
example.com.dlv.verisign.com. IN DLV 50148 5 1 (0CAE34D C1BDE4A5D12A777A8DEC3B703E516DC71)
```

This DLV has been edited to use multiple lines using the normal zone file method of enclosing in parentheses for presentation reasons only, and from inspection and comparison with the DS RR from the previous example files, it may be seen to be functionally identical.
Depending on the operational or business requirements of the lookaside zone service operator, the DLV RR may need to be sent by a secure process. While the data itself is not sensitive, secure transmission allows the recipient to authenticate the sender, not just the data. In the case of the VeriSign Pilot, the DLV RR is synthesized when the zone is registered on the project’s secure web site (https://www.dlv.verisignlabs.com). The submitted zone is inspected by VeriSign software by querying for DNSKEY RRs at the zone apex, and it will automatically create and add to its database a DLV RR for any DNSKEY RR with a flags field value of 257 (the SEP or KSK bit is set). This type of procedure may or may not become common practice, but it certainly demonstrates a level of automation that would also be practical for DS RRs.

**Note** The VeriSign Pilot requires that the DLV RR points to a KSK; that is, the DNSKEY RR has a flags value of 257 as described earlier (the SEP bit is set)—therefore a separate KSK and ZSK are required per the recommended practice.

To configure the name server to use the DLV service requires two changes to the named.conf file. The first involves definition of the lookaside zone name (in a dnssec-lookaside statement), and the second requires the inclusion of a trusted anchor for the DLV zone. The trusted anchor for the pilot project (at the time of writing there were two such anchors) may be obtained from https://www.dlv.verisignlabs.com/trusted.html. This is a secure web page, and users are recommended by text on the page to verify the security certificate—a simple but effective authentication process—before using the public keys defined, which may be simply cut and pasted into the named.conf file as shown in the following fragment:

```
// named.conf DLV fragment
...
options {
    ....
    dnssec-lookaside "." trusted-anchor "dlv.verisignlabs.com";
    ....
};
trusted-keys{
dlv.verisignlabs.com. 257 3 5
    "AwEAAbw2HZErA6PpTSVdEdvV1I1ly3gTFAhJPAscC7oa
tIr/P3hDq7sUjDy4rVHQPNjKvQMv2v0AQTyrykry021
gWQmBZjsYxyK219A1AHv5C44TsiskIN8IP28KKM1Cqmg+
10BFPJGvz73oH1eRapnCCiZ5q0dhecgFQWag/FupH
qq7sniEysUdby/9209dlDQeL9xJn1CVtMiCxfB5/ju
hV9bdWIsdLklootqniS42cjsyCGwxsFZxHQ3mh/G0
df1KnG8ENBnpxsYtJk4qOgYP5AkNAPTGoj1Kdma2f9v
16wZAIYVkcQKPusBYbUcFrxnGKPGY3Cnys=";}
dlv.verisignlabs.com. 257 3 5
    "AQPAQR5KGNz12Q/IPhkmGmv6ZIAl7rw4/7cysZju0vWd
bFuOGCwwiRv2F7b2MQIKCglUjqjZ2ZTXTAayBMSadqFoV
Cc/C16CFuQN+iMNNKgZs5sl8qI0jKMiyl+/v0/OwhL
OCurFoObuyNJXouKuoO9w1i3p0KiWQRKbnLw1c6qeqFsAN```

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The VeriSign DLV Pilot provides support to cover the whole hierarchy of the domain name to the root and therefore recommends a dnssec-lookaside statement with a . (root) domain as shown in the preceding example. The effect of this definition is that every secure zone for which there is no parent DS RR and no trusted anchor will incur a DLV query to the domain dlv.verisignlabs.com, which may be an unacceptable overhead. If the user wants to limit this process to only the .com domain, the following alternative statement could be used:

dnssec-lookaside ".com" trusted-anchor "dlv.verisignlabs.com";

In this case, only domain names ending with .com will incur a DLV lookup. Similarly, this could have been limited to .at or .org domains or multiple dnssec-lookaside statements used to select only the .de and .org domains, depending on requirement. The trusted anchor name of dlv.verisignlabs.com is unique to the current VeriSign Pilot project and references entries (in the preceding case two) in the trusted-keys clause with the same name.

**DLV Service**

There is nothing magical about a DLV service. A DLV service uses a standard name server with a standard signed zone file and could be created for use by any affinity group as an alternative to multiple trusted anchors for each member of the group. To illustrate creation of a DLV service, assume an affinity group comprised of the domains example.org, example.com, and example.net decide to set up a DLV service that will hosted by dlv.example.com. In the absence of any special software as used by the VeriSign Labs Pilot, each member domain will create a DLV RR by the zone signing process described using a `-l dlv.example.com` argument. The DLV RRs are sent to the domain administrator for dlv.example.com by a process that will authenticate the sender, such as secure e-mail. A zone file comprising the supplied DLV RRs will be created as shown here:

```plaintext
; zone fragment for dlv.example.com
$TTL 1d ; zone default
$ORIGIN dlv.example.com.
@ IN SOA ns1.dlv.example.com. hostmaster.dlv.example.com. ( 2005032902 ; serial
10800 ; refresh (3 hours)
15 ; retry (15 seconds)
604800 ; expire (1 week)
10800 ; minimum (3 hours)
)
NS ns1.dlv.example.com.
NS ns2.dlv.example.com.
ns1 A 192.168.254.2
ns2 A 192.168.254.3
; DLV RRs for affinity group
```
A ZSK and KSK for the dlv.example.com zone will be created using the dnssec-keygen utility and added to the zone file as described earlier, and the zone will be signed with the dnssec-signzone utility using both KSK and ZSK as normal. The public key of the KSK for dlv.example.com is distributed to be used as a trusted anchor by all the members of the affinity group; thus a single trusted anchor is used to replace the alternative of three trusted anchors, which would otherwise be required.

The zone dlv.example.com would be delegated from example.com and an authoritative-only name server (see Chapter 7) created to support the service. Finally, each member would add the trusted anchor for dlv.example.com in a trusted-keys clause in their named.conf file, and to invoke the service each member would further add the following three lines to the options clause in the same named.conf file:

dnsssec-lookaside "example.com" trusted-anchor "dlv.example.com";
dnsssec-lookaside "example.net" trusted-anchor "dlv.example.com";
dnsssec-lookaside "example.org" trusted-anchor "dlv.example.com";

The specification of dnsssec-lookaside says that any domain at or below the defined domain name will use the lookaside zone defined in the trusted-anchor option, which means that only domain names ending with example.com, example.org, or example.net will incur a DLV lookup. However, the specification also says that the deepest domain name (which actually means the one with the most labels) defined in a dnsssec-lookaside will be used for the lookaside query. So if a name server that included the previous three lines also wished to use, say, the VeriSign DLV Pilot service, it would add the following statement to invoke that DLV service:

dnsssec-lookaside "." trusted-anchor "dlv.verisignlabs.com";

The effect of this statement would be that any secure domain that does not end with example.com, example.org, or example.net would incur a DLV lookup to the dlv.verisignlabs.com lookaside domain, whereas only our three target domains, example.com, example.net, and example.org, would query the dlv.example.com lookaside domain. It is therefore possible to support a number of concurrent DLV services, each of which may target specific markets or affinity groups prior to the widespread availability of signed TLDs.

Summary

This chapter describes the theory and implementation of DNSSEC (colloquially known as DNSSEC.bis), which represents the second generation of standards used to ensure the authenticity and integrity of data supplied from a suitably configured authoritative name server to a security-aware requesting name server. DNSSEC standards use public key (asymmetric) cryptography to ensure that the data supplied in response to a query for, say, www.example.com, could only have come from the domain example.com (authenticity), that data received by the querying name server is the same as the data sent by the queried name server (data integrity), and that in the event www.example.com does not exist, it can be proven that such is the case.
proof of nonexistence or denial of existence). Transaction security, used to secure operations such as DDNS or zone transfer, is covered in Chapter 10.

The chapter described the establishment of islands of security whereby single, unconnected zones may be secured, or a group of such isolated islands that are part of an affinity or common interest group, such as an enterprise network, may be secured. In this case, to get security coverage the zone requires a trusted anchor—the public key used to sign the secured zone—which is obtained by a secure process that authenticates the source and is then configured into all security-aware name servers that wish to validate responses for the zone using a trusted-keys clause. Securing the zone involves the use of a private key to digitally sign all the RRsets in the zone using an RRSIG RR type. Once established, secure zones can be linked together into chains of trust using their delegation points; thus if example.com is secured, it may be linked to the .com gTLD or it may be securely delegated to sub.example.com. This process is accomplished using the Delegated Signer RR, which is added to the parent domain and secures the delegation to the child domain. The public keys used in signing are defined in the zone file using DNSKEY RRs and are categorized as either a Zone Signing Key, which is used to sign the records within the zone file and a Key Signing Key, which is used to sign only the DNSKEY RRs used in the signing process and may be used externally as either a trusted anchor or referenced by a DS RR. While the standards allow a single DNSKEY RR to be used for both ZSK and KSK purposes, this is not a recommended practice. Proof of nonexistence is provided by the NSEC RRs, which chain together all the RRs within the zone file. Cryptographic keys need to be changed either periodically to minimize risk or immediately in the case where a key is known to be compromised. This process, called key rollover, may use either a prepublish or double-signing strategy, both of which were described. Finally, examples illustrating the implementation of DNSSEC and covering all the preceding points were presented.

DNSSEC provides very positive benefits but does introduce new levels of discipline, particularly with regard to time—signatures (RRSIG RRs) in secured zone file have a finite validity period and thus require to be re-signed at periodic intervals. If the signatures are allowed to expire, the data from the zone will be marked as bogus by receiving security-aware servers.

The next chapter describes, with examples where appropriate, the statements and clauses used in named.conf, the configuration file that controls BIND's operational behavior.